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numerous and valuable, and are sure of popular recognition and reward; but they often come from the most unexpected quarters. No one can predict what wonderful points of contact may be suddenly revealed between a purely theoretical investigation and the practical utilities of life. Meanwhile, a deeper insight into the laws of the material universe, extorted from a reluctant nature only after long and patient labor and thought, and many disappointments, becomes a permanent possession for mankind; and, as long as man does not live by bread alone, it is for him a perennial blessing. The academy, in awarding the Rumford premium to you, has indicated the kind of scientific work which, in its opinion, tends most to promote the *highest* good of mankind.

I ask you to accept, with these medals, my warm congratulations, and the cordial good wishes of all the members of the academy here assembled to administer Count Rumford's trust.

On receiving the medals, Professor ROWLAND spoke as follows: —

MR. PRESIDENT, AND GENTLEMEN OF THE ACADEMY, I thank you for the honor you have conferred upon me, which I can but regard as the greatest honor of my life.

In receiving these medals, I am pleased to think that they have been conferred upon work which is not the result of a happy accident, but of long and persistent endeavor.

There are some investigators whose disposition permits them to follow their aim, inspired by the mere love of the labor and the work. There are others to whom the sunshine of appreciation is necessary. To either class, appreciation, when it comes, is always acceptable; and I assure you that the judgment set upon my investigations by this academy is highly valued by me.

It has been intimated that a short account of my work would be of interest to the members of the academy. My attention was first called to the construction of dividing-engines by an inspection of a dividing-engine constructed by Prof. W. A. Rogers, at Waltham, in this state. On returning to Baltimore, I devoted much time to the general problem of such machines; and, through the liberality of the trustees of the Johns Hopkins university, I was enabled to construct an engine. In about a year this engine was finished. It worked perfectly the moment it was put together, and it has not been touched since. In order to rule diffraction-gratings, I reflected that it was necessary that the screw should be perfect, and that the rests for the plate which receives the ruling should also be as perfectly adjusted as is necessary in optical experiments.

The process of making the screw consisted in grinding it in a long nut in which it was constantly reversed. When this screw was finished, there was not an error of half a wave-length, although the screw was nine inches long.

When the dividing-engine was completed, my mind was occupied with the problem of the best form of surface to receive the ruling. I speedily discovered, that, by ruling the lines on a concave mirror of long focus, I could dispense with a collimator and with the ordinary arrangement of lenses. I now rule gratings six inches long, with various numbers of lines to the inch. I find that there is no especial advantage in having more than fourteen thousand to the inch, with the ordinary conditions of ruling. Having made the concave grating, I invented a simple arrangement for mounting it, so that a photographic camera should move along the arc of a circle at one end of a diameter, upon the other end of which the grating was placed, and always remain in focus. With this apparatus, one can do in an hour what formerly took days. Moreover, the spectra obtained are always normal spectra, and every inch on a photograph represents a certain number of wavelengths.

After finishing my apparatus, I found it necessary to study photography; and I therefore devoted much time to this subject, and made a special study of all known emulsions. I discovered that an emulsion containing eocene enabled me to photograph from the violet down to the D line; and other emulsions were used for the red rays. I have also been engaged in enlarging my negatives and in printing from these negatives. On these enlarged photographs lines are doubled which have always been supposed to be single. The E line is easily doubled. My map of wave-lengths is based upon Prof. Charles S. Peirce's measurements of the wave-length of a line in the green portion of the spectrum.

At the conclusion of Professor Rowland's remarks, many questions were asked in regard to his beautiful device for photographing the spectrum, and the enlarged photographs which he showed were carefully examined.

PROGRESS OF ELECTRICAL SCIENCE DURING 1883.

THE subject of electrical science has become so broad that he who desires to keep abreast of the line of advance, and also to be on some points in advance of others, must read an immense amount in the English, French, German, and Italian journals, and in the patent-office reports of the various civilized nations. This is generally recognized; and courses in electrical engineering have been established in England, and are about to be established in America. This increase of intelligent appreciation of the magnitude of the subject of electricity is one of the features of the past year.

Perhaps the most important text-book that has appeared during the year is the English translation of Mascart and Joubert's treatise on electricity, with new notes by the authors. Clausius, also, has published a treatise on the theory of the dynamo-electric machine; and there have been numerous articles in various magazines upon the general subject of mathematical electricity.

The electrical congress which met in Paris, October,

1882, discussed the following questions: 1°. A redetermination of the ohm. 2°. (*a*) Atmospheric electricity; (*b*) protection against damage from telegraphic, telephonic, and electric-light wires; (*c*) terrestrial currents on telegraphic wires; (*d*) establishment of an international telemeteorographic line. 3°. Determination of a standard of light.

After a prolonged discussion, it was concluded that further experiments upon the unit of electrical resistance were necessary before a standard ohm could be adopted; and the governments participating in the congress were invited to encourage independent determinations of this unit. The section on earth-currents and lightning-conductors recommended also that the various governments should favor systematic observations, and that independent lines should be provided for the study of earth-currents; that long subterranean telegraphic lines should be used also for this purpose. The section on the standard of light were in favor of employing as a standard the light emitted by a square centimetre of melting platinum. The congress was adjourned to October, 1883; and afterwards the French government notified the various governments participating in the congress, that April, 1884, would be a more agreeable time to the majority of the congress than October. It is probable, therefore, that the congress will re-assemble during the coming spring.

Since the last meeting of the congress, various new determinations of the ohm have been made. E. Dorn, by a modification of Weber's second method, used also by Kohlrausch, has obtained the following value:—

$$1 \text{ S. E.} = 0.9482 \times 10^{10} \frac{mm}{\text{sec.}},$$

where S. E. denotes the Siemens or mercury unit. Lord Rayleigh has obtained .986 as the mean of the results of three independent determinations of the British association unit. Professor Rowland is at present engaged upon a careful redetermination of the ohm, using his apparatus for determining the mechanical equivalent of heat as a check upon the electromagnetic methods.

The subject of the cause of electromotive force obtains and deserves attention. Exner has maintained that there is no known case of chemical action without the development of electricity, and also of the development of electricity without chemical action. Braun controverts this conclusion. Exner finds that in a cell with zinc and platinum electrodes, and iodine or bromine as the liquid, a difference of electrical potential is obtained, notwithstanding the fact that iodine and bromine are elements, and cannot, therefore, be electrolytes. Exner believes the cause of this current is to be sought in chemical change. Braun shows that Exner did not take sufficient precautions to insure the purity of the iodine and bromine, and also to prevent the disturbing influence of the aqueous vapor in the air. He shows that there are numerous cases in which we have a development of electricity without chemical action, and also strong chemical action without the development of electricity. It is beginning to be perceived that the subject of thermal chemistry requires also a consideration of electromotive force.

In a voluminous paper containing a large series of observations, Quincke endeavors to verify Maxwell's conclusion that the square root of the dielectric constant must be equal to the index of refraction for light of the same substance. The several methods adopted give results which are not in accordance with Maxwell's theory of light. Quincke explains the different results obtained by different observers, as follows: 1°. Experiments show a fluctuation in the values of the index of refraction which is due to the electric force; 2°. A comparatively long duration of the electric pressure causes a fall in the value of the index of refraction equivalent to the effect of a rise of temperature between 0.0001° and 0.1° C. (this increases with the difference in potential between the electrodes, and can be attributed to internal friction caused by electric attractions and repulsions between the particles of the fluid); 3°. The phenomena of the change of the index of refraction show that the electric pressure has no analogy with hydrostatic pressure; 4°. These changes in the index indicate changes in hydrostatic pressure in the interior of the fluid, which are caused by the electrical pressure, the fluid being set into vertical movements thereby; 5°. The electrical effects appear to be transmitted through the fluid by impulses, and not in a continuous manner.

Julius Elster and Hans Geilel show that Zamboni's dry piles can be used as accumulators. The copper pole of the pile is connected with the positive, and the tin pole with the negative, pole of a Holtz machine. After the latter has been worked for a few minutes, the dry pile is found to be charged. After repeated discharges, the pile is found to contain a charge of considerable intensity. The authors recommend the following form of pile. The plates of the pile are strung, by means of a needle, upon a silk thread, and then stretched between the poles of a Holtz machine. A pile of eleven thousand pairs of plates, of one square centimetre surface, after ten minutes' charging, gave sparks one millimetre long, and made a Geissler tube luminous. The light of the tube was continuous at first, and afterwards intermittent. These piles are well suited to exhibit to a large audience the principle of Planté's or Faure's accumulators.

An interesting report upon the transmission of power by electricity was presented by Cornu to the French academy in April, 1883. This report was that of a commission appointed to examine the experiments of Depretz. It was found that the work absorbed by the generatrix, and transmitted to the receptrix, increases with the velocity of the generatrix. Depretz has succeeded in transmitting nearly four and a half horse-power through a resistance of a hundred and sixty ohms, which represents a double telegraph-line of eight and five-tenths kilometres. The work received was thirty-seven and a half per cent of that spent. With a greater velocity of the generatrix, it seems possible to transmit power to greater distances than Depretz has attained. This

amounts to saying that a high electromotive force is necessary for this end.

Many experiments continue to be made upon the magnetizing-function of steel and nickel. Hugo Meyer has experimented with weak magnetizing-forces, and finds that, 1°, the magnetizing-function has a positive value for a diminishing magnetizing-force; 2°, it increases at first with the magnetizing-force; 3°, it increases, for weak magnetizing-forces, with the temperature. Professor Ewing of Tokio, Japan, maintains that soft iron can be far more retentive of magnetism than steel. His results and detailed experiments are awaited with great interest.

Experiments made in the physical laboratory of Harvard university during the year have shown that the action of magnetism upon the conduction of heat, which has been maintained by several investigators, does not exist in magnetic fields which are at least ten thousand times the strength of the earth's field in Cambridge; and doubts are thrown upon such an action in general.

Hall's phenomenon continues to attract attention. As is well known, Mr. Hall has shown that an electrical current, traversing a thin plate of metal which is placed in a strong magnetic field perpendicular to the lines of magnetic force, has an electromotive force exerted upon it. At first it was supposed that this showed that an electrical current could be affected independently of the medium through which it passes. Mr. Hall, however, showed that the effect was different in different metals, and that the first conclusion was untenable. Aug. Righi has modified Mr. Hall's apparatus, and has discovered that the action in bismuth is extraordinary, being five thousand times as strong as in gold. The effect in bismuth can be obtained with a permanent magnet; and Righi hopes to show the phenomenon by means of so feeble a force as the earth's magnetism.

Edlund has broached a theory that a vacuum conducts electricity, and that the high resistance in rarified tubes is due to a contrary electromotive force at the electrodes in the Geissler tubes. He showed, that, without the employment of electrodes, one can excite an induction current in a Geissler tube which is sufficient to produce light. He maintains that this would be impossible if the highly rarified gas were an insulator.

Among the comparatively new electrical instruments which have been described during the year, are modifications of Lippman's electrometer. This consists, as is well known, of a capillary tube, connecting at one end with a comparatively large receptacle of mercury, and at the other with a vessel containing diluted nitric acid. The superficial tension at the end of the thread of mercury in the capillary tube is changed by a difference of electrical potential. The terminals of a Daniell cell — connected, one with the acid, and the other with mercury — cause a movement in the mercury-column, which gives a standard by which electromotive forces in general can be estimated. The instrument is very sensitive, but requires great care to prevent inaccurate measurements. A. Chevet has devised a modification of Lippman's instrument, which he claims will show a difference of potential of $\frac{1}{1000}$ to $\frac{1}{10000}$ of a Daniell cell. Two flasks, with lateral orifices on the same horizontal line, are connected through these orifices by the tube of a thermometer open at both ends. The bulb-end enters the flask A, which is filled with mercury. The capillary end enters the flask B. This latter flask is filled partly with mercury, and partly with water acidulated with a tenth part of sulphuric acid. The capillary end of the thermometer enters the acidulated water. A platinum wire, P, insulated by a vitreous covering so as not to be in contact with the acidulated water, is in contact with the mercury of flask B. Another platinum wire, N, is in contact with the mercury of the flask A. By means of a commutator a difference of potential can be intercalated between the ends of P and N. The heights of the mercury and water in the flasks A and B are such, that, P and N being connected by a metal wire, the surfaces of separation of the liquids are in the region of the capillary portion of the larger end of the thermometer-tube. The movements of the meniscus is observed with an eye-piece. Electrometers of the class of Lippman's can be constructed by any one at comparatively no expense, and are already used by physiologists. Hard-headed physicists, however, regard such instruments with considerable doubt when quantitative measurements are to be made. The subject of electrometers in general is very important from the point of view of the exigencies of meteorological bureaus and the signal-service. Modifications of Sir William Thomson's instruments still maintain their pre-eminence. Among these modifications is an instrument invented by Edelmann of Munich, in which the box-shaped quadrants of Thomson are replaced by cylinders, and the flat needle also by a suspended cylinder-shaped needle. The writer of this article remembers to have seen, ten years ago, an instrument similar to that of Edelmann, which had been devised by Mr. Moses G. Farmer, formerly of the U. S. torpedo station at Newport. It is said that the insulation of Edelmann's instrument is not perfect.

The cause of the electricity of the atmosphere is still unknown. The experiments of Freeman and Blake have apparently shown that the evaporation of pure water does not produce electricity. Kalischer has lately tested the question whether the condensation of aqueous vapor is a source of electricity. He used a modification of Thomson's electrometer, and connected it, with suitable precautions, with twelve large beakers which were covered with tinfoil and were filled with ice. These beakers, in turn, were protected from extraneous electrical influences. The condensation of aqueous vapor upon the beakers produced no electrical effect which could be observed. The criticism that can be made upon the experiments of Blake and Freeman is, that on the earth's surface an immense evaporation results from salt water, and impurities in the water may produce a state of electrification. Moreover, it is impossible to experiment on evaporation on a sufficiently large scale in a laboratory. An infinitesimal amount of electricity may

be produced by evaporation, which, although too small to be observed, may yet be integrated over the surface of the earth into a large sum.

In looking back over the electrical year, we do not find any great discoveries. We notice, however, great activity in the process of refining old methods. The electrical exhibition at Vienna showed a host of applications of electricity to the arts. There was, however, no striking new invention like the telephone. In all civilized countries, the year has brought forth innumerable modifications of telephones and telephonic apparatus. When it had once been shown that even an imperfect sentence could be transmitted by electricity, the dullest inventor could discover, among the *débris* of his laboratory, magnets and electromagnets which needed but a slight twist here and there to be made into telephones. A touch of genius was necessary for the first twist; and then the whole electrical world had the seed of the invention. It is rumored that long-distance telephoning will soon be attempted with wires of low resistance.

Electric lighting continues to attract great attention; and more correct calculations are daily made, which will soon enable us to judge of the relative economy of incandescent lighting compared with gas. In an address to the Society of arts in London, the lamented Dr. Siemens — whose sudden death last December has been such a loss not only to electrical science, but to science in general — made an elaborate calculation of the cost of lighting large areas in cities, taking the parish of St. James in London as an example and also as a unit. He estimated that to light London to twenty-five per cent of its total lighting-requirements would require an expenditure of capital of fourteen million pounds, without including lamps and fittings; making an average capital expenditure of a hundred thousand pounds per district. Siemens estimated the cost of lighting by incandescence as twenty-one shillings and nine and a half pence per lamp per year; while to produce the same luminous effects in a good Argand burner costs twenty-nine shillings per year. This apparently shows that incandescent lighting is cheaper than lighting by gas, at the present price of gas.

Electric lighting seems to gain in the estimation of the public. Even the argument that if the electric-light companies were compelled to put their wires under ground the companies could not pay their expenses, and consequently that the public would lose the benefits of the electric light, has a strong influence upon many who prefer light to darkness in our city streets. The public, however, are only beginning to realize the dangers from the present method of running electric-light wires. A heavy storm at night might cause at any time disastrous conflagrations, from the electric-light wires coming in contact with other wires and with wood-work. The bulletins published by the Edison electric-light company show the great extension of his system. His plants are to be found in almost every civilized country; and the company are paying great attention to village plants.

The writer of this article is informed that the cost of lighting the great steamboat, The Pilgrim, is not far from that of gas, with a far better quality of light than gas could give. Lighting by incandescence is a great luxury; and, as soon as the public imagination has been sufficiently stimulated, it promises to become a necessity in many quarters. Other systems besides that of Edison are competing for the field opened for enterprise.

The practical applications of the storage of electricity, so called, have not been numerous during the year. It is maintained that it is more economical to use electrical accumulators than to light directly from dynamo-electric machines. There is still a wholesome fear of having several tons of lead left on one's hands in a disintegrated condition. Further experiments are necessary on an extended scale, with especial reference to a large factor of time, before electrical accumulators can be pronounced a practical success.

JOHN TROWBRIDGE.

BIOGRAPHIES OF NATURALISTS.

Heroes of science: botanists, zoölogists, and geologists. By Prof. P. MARTIN DUNCAN, F.R.S., F.L.S., etc. (London society for promoting Christian knowledge.) New York, *E. & J. B. Young & Co.* 348 p. 12°.

THE plan of the several volumes designated by the common title 'Heroes of science' is worthy of much commendation. It is a frequent and irritating experience of those who have become interested in scientific men's lives to find that they have a scant place in biographical encyclopaedias, and that even the greatest figures in that line of human activity are dismissed with epitaphal brevity of description. The proper way to meet this difficulty would be by preparing an encyclopaedia containing only the names of those who had contributed something to the store of science. 'Heroes of science' has a far simpler aim. Twenty-one names from the great muster-roll of men who may be termed naturalists are all that appear in this book. The first is that of Aristotle; the last, that of Lyell. The aim of the author is clearly to show how these men have played their parts, and something of the way in which they turned the course of science in their time. In this aim it seems to the present writer that Professor Duncan has attained a very substantial success. Within the slender space of two hundred and fifty small pages it is, of course, impossible to do any thing that can be called justice, to more than a score of very notable men, mostly of rich and varied lives; yet the reader will get a sense of their value to the world from the book, that he will not obtain elsewhere. Take, for instance, the life of Lamarck: though all too briefly told for true proportion, it is the best short account of